

DOUBLE AMPLITUDE EVALUATION IN ULTRASONIC TESTING

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INTRODUCTION

In the field of nondestructive testing with ultrasound, echo amplitude evaluation is a common practice. In scanning applications, it is transformed into a gray level and then plotted, producing the so-called C-scan plots. With this method, all other information, which is simultaneously present in the A-scan, is disregarded.

In this paper an evaluation based on pattern recognition is described, which enables the user to handle more than one piece of information for his C-scan plot. Contrary to normal pattern recognition, which evaluates different features of one echo, this method handles two different echoes together with thickness information and applies a physically based evaluation function as the discriminant. In the following section the hardware and the possibilities are outlined; and, in the third section, four different applications, where this method presents advantages, are described.

HARDWARE AND DISCRIMINANT FUNCTIONS

In Fig. 1 a typical set-up for a scanning application is given. The flaw detector is equipped with two independent gates, such that one gate is preferably equipped with a backwall echo attenuation. Both gates deliver a DC voltage which is proportional to the maximum echo amplitude in the gate. In addition, a wall thickness meter with an artificial zero control is used, which delivers time-of-flight values. All information is updated with a pulse repetition frequency of (< 8 kHz) and fed into the C-scan processor for further processing. After this evaluation, the result is transferred as an analog gray information to a gray-scale plotter or is used as digital information by an external computer.

Fig. 2 presents a more detailed picture of the C-scan processor. The upper four evaluation functions are conventional; the remaining ones use the ratio and the product of the two amplitudes as a discriminant function, which corresponds to the "dB-difference" and the "dB-average" since the logarithm is used. The discriminant function $\log(A_1/A_2)/T$ reflects the attenuation law and enables the user to directly plot the attenuation coefficient.

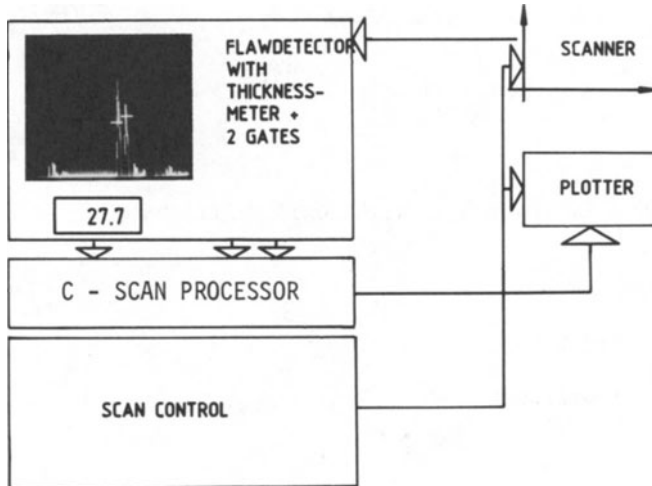


Fig. 1. Test set up

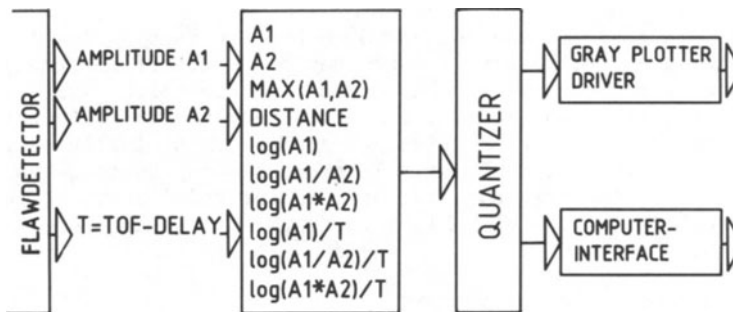


Fig. 2. C-scan processor

APPLICATIONS

Compensation of Varying Attenuation

In Fig. 3, the ultrasonic picture of a test piece of austenitic material is displayed. The upper plot shows the attenuation in the material varying from left to right by more than 20 dB. The center picture shows the scan result of a row of 3 mm flat-bottom holes. The holes farthest to the right are, of course, heavily masked by the increased absorption. By taking the backwall echo as a normalization echo, the true gray level of the flat-bottom holes can be reconstructed as shown in the lower part of the figure.

An important feature in this evaluation scheme is the fact that the echo amplitude and the backwall amplitude are derived simultaneously from only one shot.

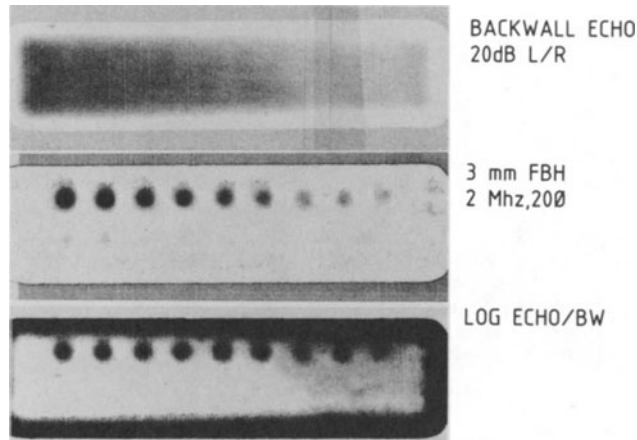


Fig. 3. Compensation of varying attenuation

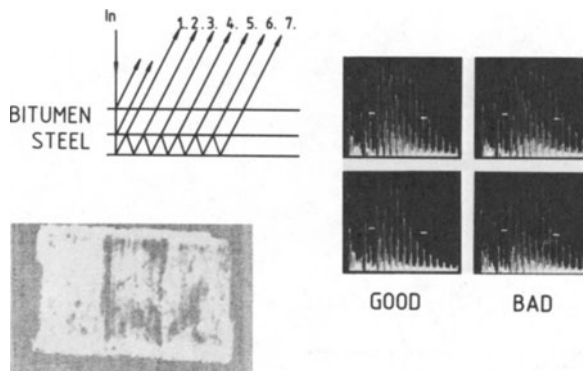


Fig. 4. Bond test with a resonant method

Bond Test with a Resonant Method

The bond between two layers can be tested most reliably with a resonant method. The decay of a backwall echo series in one layer is observed in such an experiment. If the bond is good, the energy transfer from one layer to the other is working and the backwall echo series decays more rapidly. By observing the n -th backwall echo amplitude the energy transfer takes place n times, thus increasing the small effect to a measurable quantity. A problem could occur if the starting amplitude of the decay series is not precisely known, due to varying absorption in the upper layer or effects of the affected bond interface. In Fig. 4 a bitumen/steel interface is tested. Two good and two bad backwall echo series can be seen, which show that there are absorption differences in the bitumen layer of approximately 6 dB and a disbond effect on the same order. A bond test is, therefore, only feasible when the ratio of the 9th and the first backwall echo is calculated thus removing amplitude variations from the upper layer.

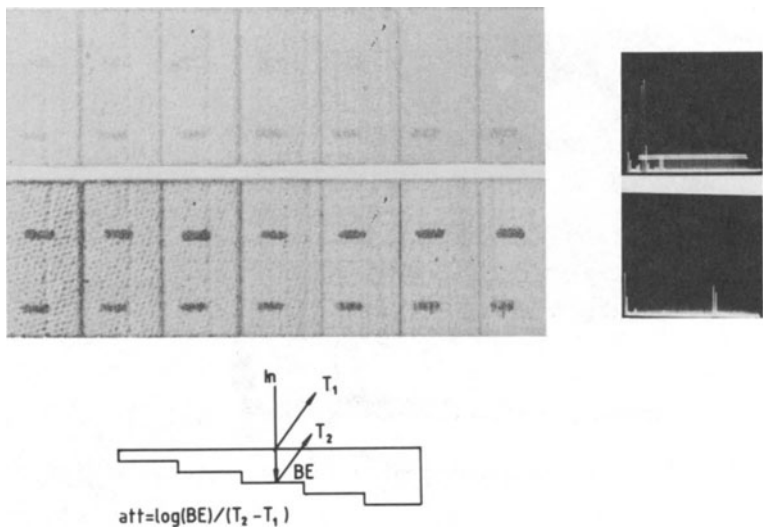


Fig. 5. Attenuation of a CFC scale, thickness compensated

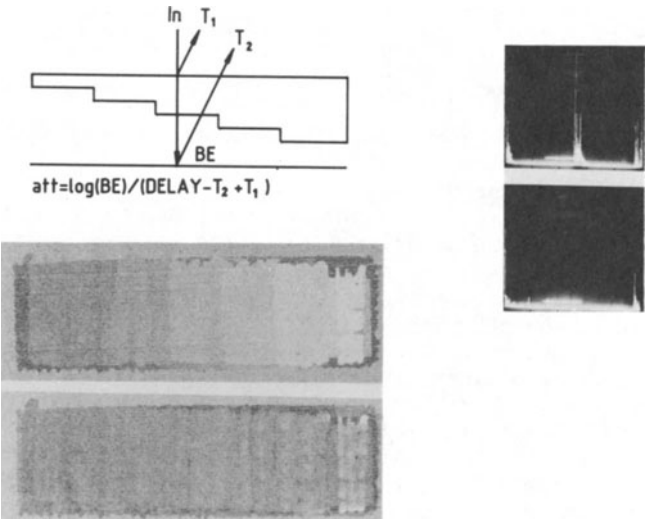


Fig. 6. Thickness compensation, aux. reflector

Thickness Compensations in Attenuation Measurement

The attenuation of the material can be derived from the amplitude of the backwall echo. Of course this also depends on the thickness of the test piece. In Fig. 5, top picture, the C-scan plot of a CFC-scale can be seen. Due to the increasing thickness of the scale, the gray level at the right side is darker than that on the left side. If the amplitude is normalized by the thickness, the gray level is equalized. On the left side, the resolved structure also gives an additive black impression. In this example, the following advantages need to be demonstrated: Up to an additional 26 dB gain control range to the normal DGS compensation, no speed problems in the gain control and a calibrated attenuation value.

Thickness Compensation in Through-Transmission

In through-transmission or by using auxiliary reflectors, a thickness compensation in the usual way as described above is not applicable. Due to the higher sound velocity in the test piece compared to water, a higher thickness produces an echo which arrives earlier (Fig. 6). A correct thickness compensation is then possible by using the artificial delay of the wall-thickness meter to compensate for the total water path. The measured thickness value registers negative. But, since the C-scan processor using only the absolute value of the time-of-flight value, the compensation is still correct. Fig. 6 illustrates a CFC step block, again with a dynamic range greater than 26 dB, whereby the attenuation is thickness-compensated by this method.